Board Structure and Price Informativeness*

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This Version: April 2008

Abstract

We develop and test the hypothesis that private information incorporated into stock prices affects the structure of corporate boards. We find a negative relation between measures of the amount of private information incorporated into stock prices (*price informativeness*) and measures of board independence. This finding is robust to the inclusion of many firm-level controls – including firm fixed effects – and to the choice of the measure of price informativeness. Consistent with the hypothesis that price informativeness and board monitoring are substitutes, this relationship is particularly strong for firms more exposed to both external and internal governance mechanisms, and firms for which firm-specific knowledge is relatively unimportant. Our results suggest that firms with more informative stock prices have less demanding board structures.

JEL classification: G32, G34
Keywords: Corporate boards, Independent directors, Price informativeness, Monitoring

*We thank Art Durnev, Carola Frydman, José-Miguel Gaspar, Itay Goldstein, Jeffrey Gordon, Antoine Faure-Grimaud, Walter Novaes, Wayne Mikkelson, Raghu Rau, Pedro Santa-Clara, Antoinette Schoar, and Laura Starks; seminar participants at University of Texas-Austin, City University of London, EBRD, LSE, Tilburg University, University of Bristol, Universidade de Évora, Universidade Nova de Lisboa; and participants at the Lisbon-Sloan MIT corporate finance and governance workshop, the Luso-Brazilian Finance Meeting (Lubrafin), and the Hitotsubashi University conference on Corporate Governance for helpful comments and suggestions.

1. Introduction

The view that prices aggregate information that is dispersed among market participants dates back to at least Hayek (1945). The modern version of such an idea is found in, among others, the works of Grossman and Stiglitz (1980) and Kyle (1985), in which the main role of stock markets is the production and aggregation of information as a consequence of trading between speculators and other types of (perhaps less informed) investors. The idea that this type of information can also be useful for the provision of incentives in firms and for the design of corporate governance mechanisms is a more recent one. Articles by Holmstrom and Tirole (1993) and Faure-Grimaud and Gromb (2004) examine the role of stock prices in disciplining managers and providing incentives to insiders. There is also a set of related studies on the role of stock prices in guiding corporate investment decisions (Dow and Gorton (1997) and Dow, Goldstein, and Guembel (2007)).

Our most important contribution is to document a robust negative relation between proxies for price informativeness and board independence. This is a novel and surprising finding, and one that deserves further scrutiny. In most of our empirical specifications, our measure of price informativeness is the probability of informed trading (PIN), which was developed in a series of papers beginning with Easley, Kiefer, and O'Hara (1996) and Easley, Kiefer, and O'Hara (1997). But the results are unchanged when we use alternative proxies for the impact of private information on prices, such as firm-specific stock return variation (Morck, Yeung, and Yu (2000)) and a measure of illiquidity or price impact of order flow (Amihud (2002)). We also investigate the impact of price informativeness on additional characteristics of the board of directors. We find that price informativeness is positively related to the number of directors with attendance problems and negatively related to the number of board meetings. These results are compatible with board monitoring and price informativeness being substitutes.

The most natural reaction to unexpected empirical findings is to consider the possibility of omitted variables. We show that the negative correlation between price informativeness and

board independence remains strong after controlling for a long list of possible covariates. This correlation is not explained by firm size and complexity, performance, governance variables, and ownership structure variables, among others. In fact, the results are unchanged after the inclusion of firm fixed effects, suggesting that time-invariant unobserved firm characteristics cannot explain our empirical findings. Thus, we are able to rule out many of the possible explanations for such a finding, mainly the ones associated with omitted variables.

After ruling out most omitted variables explanations, the next question we turn to is whether we can say anything about the direction of causality. We use instrumental variables (IV) methods to estimate the effect of price informativeness on board independence. As instruments, we use variables that are known to be correlated with price informativeness, such as share turnover, analyst coverage, and S&P 500 membership, but have never been used as explanatory variables in board independence regressions in previous studies. Alternatively, we show that using lagged versions of the price informativeness variable also yields similar results. Although it is not possible to prove the validity of the instruments, our findings suggest that at least part of this correlation can be explained by price informativeness affecting board structure. However, we cannot rule out the possibility that causation runs in both directions, because they are not mutually exclusive. It would be interesting to investigate whether board structure also affects price informativeness, but in the absence of good instruments for board structure, this may not be feasible.

We also develop a simple model that rationalizes the evidence. The role of the model is simply to clarify the role of price informativeness in the choice of board structures. We argue that the information revealed by stock prices should affect how directors perform their monitoring of management. We identify two intuitive mechanisms by which prices may affect board monitoring. On the one hand, the information revealed by stock prices allows external monitoring mechanisms to operate more efficiently. For example, if prices fall due to the announcement of value-decreasing investments, the firm becomes a cheaper takeover target. Managers who value control would thus avoid undertaking such value-destroying

projects. Thus, stock markets play an important monitoring role. On the other hand, more informative prices bring new information to both markets and boards. Directors may use the information revealed by stock prices as an input to their monitoring task. Arguably, a better informed board of directors should be a better monitor.

Our model predicts that price informativeness matters for board monitoring, but that the sign of this relationship is ambiguous. Changing board structure in the direction preferred by shareholders may be difficult (i.e. costly), especially when ownership is dispersed, in which case coordination costs arise. More informative prices make boards more effective, but also reduce the need for board independence. Thus, whether price informativeness and board independence are substitutes or complements is in the end an empirical question. Our model, however, has some unambiguous predictions that we also explore in our empirical analysis. We find that the negative relationship between price informativeness and board independence is particularly strong for firms with few takeover defenses, for firms with a high concentration of institutional ownership, for firms with low R&D expenses, and for firms in which CEO pay-performance sensitivities are high. These findings are all consistent with the theory and, considered together, they increase our confidence in the interpretation of the results.

A crucial assumption behind both our theoretical analysis and our empirical strategy is that different stocks have different amounts (in a relative sense) of information incorporated into them. This heterogeneity in price informativeness arises due to the different costs of collecting and producing private information. Grossman and Stiglitz (1980) predict that improving the cost-benefit trade-off of private information collection encourages more extensive informed trading and leads to more informative pricing. They suggest that in a market with many risky stocks, those which can be investigated more cheaply are more attractive to traders. As traders acquire more information about such stocks, their prices become naturally more informative.

The measure of price informativeness that we use in most of our specifications – PIN –

has strong theoretical foundations, since it comes from a structural microstructure model. A high PIN indicates that relatively more of the information incorporated into a stock's price is coming from private sources than public ones. Previous empirical work generally supports the use of PIN as a valid measure of the probability of informed trading and a proxy for stock price informativeness. Easley, Hvidkjaer, and O'Hara (2002) find that the risk of private information trading is priced. Vega (2006) shows that stocks with higher PIN have smaller reactions following an earnings announcement. Chen, Goldstein, and Jiang (2007a) adopt this measure to assess the impact of price informativeness on corporate investment. Our work provides complementarity evidence on the importance of price information for corporate decisions by focusing on the relationship between price informativeness and governance mechanisms, which ultimately determine investment decisions.[1]

Overall, our results suggest that, empirically, board independence and price informativeness are substitutes rather than complements. There are few empirical studies on the interaction between different governance mechanisms. Mikkelson and Partch (1997) find evidence consistent with the effectiveness of board oversight being enhanced by an active takeover market. More recent examples include the work of Cremers and Nair (2005), who find a complementary effect between openness to the market for corporate control and large institutional investors presence, and Gillan, Hartzell, and Starks (2006), who find that an independent board can act as a substitute for the market for corporate control. Our paper adds to this growing literature.

Our results are also consistent with the idea that the optimal board structure depends on the characteristics of the firm; that is, "one size" does not fit all firms. In particular, there is some evidence consistent with board structure being affected by the degree of complexity of firms' operations and the trade-off between the costs and benefits of advising and monitoring management (Boone, Field, Karpoff, and Raheja (2007), Coles, Daniel, and Naveen (2008),

[1] Kau, Linck, and Rubin (2008) also provide evidence that stock prices provide information for managers. They show that managers are more likely to cancel investments decisions when the announcement effect of such investments is negative.

and Linck, Netter, and Yang (2008)).

On the theoretical side, our model integrates two independent lines of research. The first one explains board structure as the result of optimal shareholder choices under incomplete contracts (Hermalin and Weisbach (1998), Raheja (2005), Song and Thakor (2006), Adams and Ferreira (2007), and Harris and Raviv (2007)). The second one examines the role of stock prices in disciplining managers and providing incentives to insiders (Holmstrom and Tirole (1993), Faure-Grimaud and Gromb (2004), and Almazan, Banerji, and Motta (2007)). To the best of our knowledge, these two strands of the literature have never before been put together.

The remainder of the paper is organized as follows. In Section 2 we present a simple model to motivate the relationship between stock price informativeness and board independence. The model is used to derive the hypotheses that we test in subsequent sections. Section 3 describes the sample, the data, and the construction of variables. In Section 4 we present our core evidence on the relationship between board independence and stock price informativeness, while in Section 5 we perform many robustness checks. In Section 6 we further investigate some of the additional implications of the model. Section 7 concludes.

2. The Model

Using a simple model, we show that there can be a link between the board's monitoring role and the information revealed by stock prices. On the one hand, more informative prices can reinforce the internal monitoring activity performed by the board of directors. On the other hand, higher price informativeness can enhance the effectiveness of external monitoring mechanisms, such as disciplining takeovers. Hence, board independence and price informativeness can interact as either complements or substitutes. We examine this trade-off and discuss some empirical predictions that are tested later in the paper.

In what follows, we take the degree of price informativeness as exogenously given and

focus on the optimal choice of board monitoring. This is not for realism, but for simplicity. Although there might be feedback effects from board structure to price informativeness, we do not explore this route in our empirical work. Thus, we choose to keep the model as simple as possible by focusing only on what is essential for the empirical analysis.

2.1. Setup

We model the need for monitoring the CEO in a simple adverse selection setting (see for example Hermalin and Weisbach (1998)) with three dates (0, 1 and 2) and four types of participants: Shareholders, a Board of Directors, a CEO, and a Stock Market. The sequence of events is as follows. At date 0, the shareholders choose the composition of the board of directors (i.e., its level of independence i) and hire a CEO of an unknown type. At date 1, the type of the incumbent CEO may be revealed. With probability p (which we interpret as the degree of price informativeness), stock prices reveal the CEO's type to everyone. If prices do not reveal the CEO's type, the board alone can learn it with probability β. If the board is informed, it may replace the CEO with a new one. Likewise, if the market is informed, an external raider might take over the firm and replace the CEO.[2] At date 2, the value of the firm is revealed to everyone. The value of the firm depends on the type of the CEO in charge.

There are two types $j \in \{H, L\}$ of CEOs in this market. At date 0, the type of the CEO is not known by anyone. For simplicity, we assume that both types are equally likely in the population. The value of the firm, V^j, will depend on the quality j of its CEO. We assume $V^H > V^L$. The unconditional expected value of the firm when a new CEO is appointed is then $V^E = \frac{1}{2}\left(V^H + V^L\right)$.

The Board of Directors is characterized by its level of independence i. This level i corresponds to the probability that the board monitors and replaces a CEO who is revealed

[2] Alternative interpretations are also possible. For example, the CEO could have made wrong decisions that could be reversed only if monitors intervene at this stage.

to be of type L at time 1.[3] The board can learn about the CEO's type at date 1 from two sources: (1) stock prices or (2) its own assessment. We assume that, if the market is uninformed, the board unilaterally learns the CEO's type at date 1 with probability β. This is a very natural assumption: Insiders (i.e., the board) know more than outsiders.

Shareholders are risk-neutral agents who care about the market value of the firm and delegate firm management to the CEO. Shareholders choose the composition of the firm's board of directors, i.e., its level of independence $i \in [0, 1]$. This choice is non-trivial since a more independent board is assumed to be costlier, but also generates more monitoring of the CEO. We assume that board independence has an ex ante cost $k\frac{i^2}{2}$ to shareholders.[4] As we will discuss below, this cost may arise due to the fact that dispersed shareholders may find it difficult to influence board composition.

The stock price will be informative at date 1 with probability p, in which case it reveals the CEO's type, which becomes public information. If the price does not reveal the type of the CEO (with probability $(1-p)$), or if it reveals that the CEO is of type H (with probability $\frac{p}{2}$), the probability of a takeover taking place is zero.[5] Conditional on the market being informed that the CEO is of type L (with probability $\frac{p}{2}$), an external raider takes over the firm and replaces its CEO with probability $\tau \in [0, 1]$, which we interpret as a measure of takeover threat (or an inverse measure of takeover defenses). If the market is informed that the CEO is of type L, the board may also directly monitor and replace the CEO with probability i.[6] For simplicity, we assume that, at date 1, τ and i are independent from each other. If both the board and the market wish to replace the CEO simultaneously, we assume that they flip a coin. Because the outcome for the firm is the same regardless of who monitors, it is not relevant to know the ultimate identity of the successful monitor.

[3] More independent boards are likely to perform their monitoring role more effectively and there is evidence that outside directors can affect crucial decisions such as hiring and firing the CEO (Weisbach (1988)).

[4] For models that endogenize the cost of board independence, see Song and Thakor (2006) and Adams and Ferreira (2007).

[5] This assumption is not crucial. The model could easily accommodate a positive probability of a raider acquiring information and placing a takeover bid, even if prices are uninformative.

[6] If prices reveal that the CEO is of type H, neither the market nor the board are interested in monitoring and replacing the incumbent CEO.

In case the CEO is replaced at date 1, his successor is randomly drawn from the population. Thus, conditional on the market and/or the board being informed, the firm's expected value is $V^M = \frac{1}{2}\left(V^H + V^E\right)$.

2.2. Board Independence and Price Informativeness

The shareholders' problem at date 0 is to choose the level of monitoring of the board of directors according to:

$$\begin{aligned} \max_{i\in[0,1]} \quad & p\left[\left(i+\tau-i\tau\right)V^M + \left(1-i-\tau+i\tau\right)V^E\right] \\ & + \left(1-p\right)\left[\beta i V^M + \beta\left(1-i\right)V^E + \left(1-\beta\right)V^E\right] - k\frac{i^2}{2}. \end{aligned} \tag{1}$$

Assuming an interior solution, the optimal board structure is characterized by:

$$i^* = \frac{1}{k}\left[p\left(1-\tau\right) + \left(1-p\right)\beta\right]\left(V^M - V^E\right). \tag{2}$$

Proposition 1 *The optimal degree of board independence varies with the degree of price informativeness according to:*

$$\frac{\partial i^*}{\partial p} = \frac{1}{k}\left(1-\tau-\beta\right)\left(V^M - V^E\right). \tag{3}$$

The sign of the relationship between board independence and price informativeness is ambiguous, depending on the values of the parameters. This result is explained by the interaction of two intuitive effects.

On the one hand, price informativeness and board monitoring can be complements – the better informed the board is, the more effective board monitoring becomes. This effect arises because price informativeness is a non-rival good that can be used by both insiders and outsiders. This result is a robust one, and not specific to our model: The public good nature of price informativeness would always generate a complementarity effect in any realistic

model.[7]

On the other hand, price informativeness can be a substitute for board monitoring. A better informed market can directly perform external monitoring via takeovers. This result arises because both internal and external monitoring mechanisms perform the same task of disciplining the CEO. Any model in which internal monitoring is costly should predict a lower level of board monitoring when there is an increase in the level of external monitoring (due to more information being available in the market).

If $\tau + \beta > 1$, board independence and price informativeness are substitutes, i.e., there is a negative relationship between price informativeness and board independence. Intuitively, the substitution effect is more likely when the probability of takeovers is higher and when the board's knowledge of firm-specific information is higher. Conversely, if $\tau + \beta < 1$, board independence and price informativeness are complements. Ultimately, finding out which effect dominates is an empirical question.

2.3. Takeover Threats

The model allows us to predict, without ambiguity, the effect of the degree of exposure to takeover threats on the relationship between board independence and price informativeness.

Proposition 2 *The higher is the likelihood of a takeover, the stronger (weaker) is the substitution (complementarity) effect of price informativeness on the choice of board independence:*

$$\frac{\partial^2 i^*}{\partial p \partial \tau} = -\frac{1}{k}\left(V^M - V^E\right). \tag{4}$$

More external monitoring makes the substitution effect between price informativeness and board independence stronger. If a disciplining takeover is more likely when the market is informed, there is less need for boards to monitor. Hence, we expect the level of board

[7] Gordon (2007) proposes the hypothesis that board independence and stock price informativeness are complements. He claims that the monitoring advantages of independent directors are more clear in an environment with increasing stock price informativeness as insiders lose their information advantage about the firm's prospects.

independence of those firms that are more exposed to the market for corporate control to exhibit higher sensitivity to stock price informativeness. In sum, the substitution effect is stronger when takeover threats are more likely. This implication could be tested by using takeover defenses as a proxy for the likelihood of takeovers. In the empirical section, we use the Gompers, Ishii, and Metrick (2003) governance index as a proxy for takeover defenses.

In sum, although our model implies that the complementarity and the substitution effects are both possible, the substitution effect is more likely to dominate when the firm has fewer takeover defenses in place.

2.4. Institutional Investors

There is evidence that institutional investors also perform an active role in corporate governance (e.g., Hartzell and Starks (2003)). Here we examine the role played by institutional investors in the relationship between board structure and price informativeness. We interpret parameter k as a measure of how costly internal monitoring is. When institutional investors are present as large shareholders (i.e., there is high concentration of institutional holdings), it is likely that this cost of board monitoring is lower.

Proposition 3 *The relationship between board independence and price informativeness is stronger when the marginal cost of internal monitoring is higher:*

$$\frac{\partial^2 i^*}{\partial p \partial k} = -\frac{1}{k}\frac{\partial i^*}{\partial p}. \tag{5}$$

We can see that (in absolute values) the relation between board independence and price informativeness is less pronounced when the marginal cost of external monitoring k is higher (i.e., when $\frac{\partial i^*}{\partial p} > 0$, then $\frac{\partial^2 i^*}{\partial p \partial k} < 0$, reducing the complementarity effect; and when $\frac{\partial i^*}{\partial p} < 0$, then $\frac{\partial^2 i^*}{\partial p \partial k} > 0$, reducing the substitution effect). These results suggest that price informativeness only significantly affects board independence when the board can *effectively* act as an internal monitoring mechanism (low monitoring cost k).

Our interpretation here is that k measures the costs to shareholders of changing the board structure. If ownership is dispersed, coordination costs are high, so k is high. On the other hand, if there is significant ownership concentration, we expect k to be low (Shleifer and Vishny (1986) and Carleton, Nelson, and Weisbach (1998)). Empirically, we use the concentration of institutional investors as a (inverse) proxy for k.

2.5. Firm-Specific Knowledge

If we consider β, the likelihood that the board learns information that is not revealed by prices, as a parameter that reflects how easy it is for the board to gather firm-specific information to assess the ability of the CEO, we can offer the following interpretation for the effect of β on the board independence-informativeness relation:

Proposition 4 *The higher is the probability that the board learns firm-specific information, the stronger (weaker) is the substitution (complementarity) effect of price informativeness on the choice of board independence:*

$$\frac{\partial^2 i^*}{\partial p \partial \beta} = -\frac{1}{k}\left(V^M - V^E\right). \tag{6}$$

Arguably, the board should find it easier to acquire firm-specific information in firms that undertake simple, well-known projects. In more innovative firms, outside board members should find it harder to acquire firm-specific knowledge that is needed to assess the CEO's ability. According to our interpretation, these firms would have low β. This result suggests that the (absolute value of the) effect of price informativeness on board independence should be stronger in firms undertaking simple and well-known projects in case the overall effect is negative, but weaker in case the overall effect is positive. Empirically, we use R&D expenditures as a (inverse) proxy for β.

2.6. Discussion of the Main Assumptions

Our model is quite simple and stylized. We believe that the most relevant ingredients are present, but acknowledge that in some instances they are oversimplified. One of the main simplifications is the formation of stock prices, which we treat as a black box. We could have developed a detailed microstructure model with endogenous price formation, but we believe that the current simple structure is sufficient to model the link between the composition of the board of directors and price informativeness.

The way in which we model the board of directors is also simplified. We could have followed the existing board literature by endogenizing all the costs and benefits of board monitoring. However, since most of those results are now well known, we believe that replicating their underlying analysis is unnecessary.

Finally, regarding the relationship between the firm and the CEO, we formulate the agency problem as an adverse selection problem (as in Hermalin and Weisbach (1998)). Alternatively, we could have presented a moral hazard problem (as in Dow and Raposo (2005) and Adams and Ferreira (2007)), in which the incentives given to the CEO would be an additional concern. Once again, since these results are well established in the literature, we have chosen the current approach for its simplicity. A more complicated setup would only distract us from the main goal of the theory, which is to provide us with some clear implications that can be tested in our data.

3. Sample and Variables

3.1. Measures and Determinants of Board Structure

Our main dependent variable is the fraction of independent directors, which is a proxy for the monitoring intensity of the board. In order for a director to qualify as independent, he or she must not be an employee, a former executive, or a relative of a current corporate

executive of the company. In addition, the director must not have any business relations with the company.

In a later section, we also consider other board structure variables. As alternative proxies for the monitoring activity performed by the board of directors, we use the annual number of regular board meetings and the fraction of directors with attendance problems (i.e. directors who attended less than 75% of board meetings).

In order to identify the effect of price informativeness on the structure of corporate boards, we need to control for other possible determinants of board structure. The literature provides many suggestions in this regard. A useful classification to organize our choice of control variables is provided by Boone et al. (2007). They group the different theories of the determinants of board structure into three broadly-defined hypotheses: *The scope of operations hypothesis*, *the monitoring hypothesis*, and *the negotiation hypothesis*.

The scope of operations hypothesis suggests that the size and complexity of a firm's operations affect its board structure (Fama and Jensen (1983)). As a firm grows and diversifies, it faces an increasing demand for specialized board members who can perform tasks such as managerial compensation and auditing. Under this hypothesis, more complex firms face larger agency costs and thus require additional board monitoring (Coles et al. (2008)).

We consider three proxies to capture firms' operational complexity: firm size (as measured by equity market capitalization), firm age (the number of years since the firm's stock is exchange-listed), and the number of business segments. We expect larger, older, and more diversified firms to have a higher fraction of independent directors, which is consistent with the findings in Boone et al. (2007), Coles et al. (2008), and Linck et al. (2008). We also add leverage to this list, because Coles et al. (2008) argue that more leveraged firms are more dependent on external resources and thus leverage can be considered as a proxy for firm complexity and the CEO's need for advice.

Boone et al. (2007) call *the monitoring hypothesis* the group of formal and informal theories emphasizing the importance of a firm's business environment for the optimal design

of its board structure (e.g., Demsetz and Lehn (1985), Raheja (2005), Adams and Ferreira (2007), and Harris and Raviv (2007), among others). We use several control variables to capture some of the elements of these theories. To control for the costs of outside monitoring, we take into account growth opportunities as proxied by the market-to-book ratio and R&D expenditures, stock price volatility as proxied by the variance of stock returns, and CEO stock ownership. We also consider free cash flow, profitability, and industry concentration, because these variables could be related to agency conflicts and other opportunities for the CEO to extract private benefits. Similarly, we include the governance index of Gompers et al. (2003) (GIM) as a measure of the number of takeover defenses in the firm's charter.

Finally, the theories in the group called *the negotiation hypothesis* emphasize the role of the negotiation between the CEO and outside directors as an important determinant of board composition (Hermalin and Weisbach (1998)). We include two measures of CEO influence: CEO's tenure and stock ownership.

We also introduce institutional ownership variables as additional controls in our empirical specifications. Because the trading activity of large institutional investors may have a direct effect on the amount of private information revealed by stock prices, we expect institutional ownership to be correlated with price informativeness. There is also evidence that institutional investors also perform an active role in corporate governance (e.g., Hartzell and Starks (2003)). Thus, omitting the institutional ownership variables may lead to spurious correlations between price informativeness and board structure.[8] Institutional investors are expected to have more influence when they are large shareholders, because they have easier access to board members (Carleton et al. (1998)) and benefit from economies of scale in monitoring activities. Thus, we consider two measures of concentrated holdings: the concentration of institutional ownership (as measured by the Herfindahl index) and institutional blockholder ownership (defined as stock holdings by the firm's largest institutional investors

[8] There is some discussion in the literature over whether some types of institutions specialize in monitoring and activism rather than trading. Research by Chen, Harford, and Li (2007b) shows that "independent institutions" (mutual fund managers and investment advisors) are effective monitors, while "grey" institutions (bank trusts, insurance companies, and other institutions) are not.

with at least 5% of shares outstanding, following Cremers and Nair (2005)). We also control for the total institutional ownership (defined as the percentage of shares outstanding held by institutions).[9]

A more comprehensive discussion of some of these variables and their relationships to board structures can be found in Boone et al. (2007), Coles et al. (2008), Gillan et al. (2006), and Linck et al. (2008). Our goal in this paper is not to replicate these works, but rather to make sure that the new results in our paper are not being driven by omitted variables that have been found to be correlated with board structure.

3.2. Measures of Price Informativeness

Our primary measure of stock price informativeness is the probability of information-based trading (PIN) developed by Easley et al. (1996). This measure is based on a structural market microstructure model, where trades may come from "noise traders" or from "informed traders." Easley et al. (2002) provide a detailed theoretical description of the PIN variable. Here we simply explain its intuition.

The trading process is modeled in the following way. At the beginning of each day, there is a probability λ that some traders acquire new (private) information about the fundamental value of the firm. Trading orders arrive throughout the day according to three different Poisson distributions: informed trade orders come in at the average rate μ, uninformed buy orders come in at the rate ϵ_b, and uninformed sell orders come in at the rate ϵ_s. The probability that the opening trade of the day is information-based is given by

$$\text{PIN} = \frac{\lambda\mu}{\lambda\mu + \epsilon_b + \epsilon_s}, \tag{7}$$

where $\lambda\mu$ is the arrival rate for informed orders and $\lambda\mu + \epsilon_b + \epsilon_s$ is the arrival rate for all

[9] We obtain similar results using alternative measures of concentrated holdings: ownership by the five largest institutional investors; ownership by institutional blockholders (defined as stock holdings by institutional investors with at least 5% of shares outstanding); ownership by all blockholders; and ownership by outside blockholders. We present some these results in the robustness section.

orders.

Easley et al. (2002) use intra-day transaction data to estimate the above parameters and thus the probability of informed trading in a stock. Notice that PIN should be low for stocks with little fluctuation in their daily buy and sell orders, which are more likely to come from liquidity or noise trading. Likewise, PIN should be high for stocks that display frequent large deviations from their normal order flows.

Previous empirical work generally supports the use of PIN as a valid measure of the probability of informed trading and a proxy for stock price informativeness. Easley et al. (2002) find that the risk of private information trading is priced, and find that it carries a positive risk premium, i.e. stocks with higher PIN have higher expected returns. Vega (2006) shows that stocks with higher PIN have smaller reactions following an earnings announcement, which is consistent with the idea that these stocks incorporate more private information and track their fundamental values more closely. PIN also seems to be related to managerial decisions. Chen et al. (2007a) find a positive relation between PIN and the sensitivity of firm investment to stock prices, which supports the hypothesis that managers learn from the private information incorporated into stock prices. Ferreira and Laux (2007) find a positive relation between strong corporate governance (few takeover defenses) and PIN, suggesting that strong shareholder protection induces private information collection and trading by informed market participants. All this empirical evidence supports the interpretation of PIN as a valid measure of stock price informativeness.[10]

Although we use PIN as our main proxy for the amount of private information that is incorporated into prices, we acknowledge that this measure is imperfect. PIN might capture some illiquidity effects that are not related to asymmetric information. If PIN is a noisy measure of asymmetric information, this will lead to an attenuation bias that is likely to reduce both the size and the statistical significance of the estimated effects of PIN on board

[10] A recent paper by Duarte and Young (2007) questions some of these interpretations. Their findings suggest that the relation between PIN and expected returns is explained by the fact that PIN is also a proxy for illiquidity that is not related to private information.

structure (under the null that there exists a relation between price informativeness and board independence). Thus, the noise in PIN is likely to work against us finding any result. We find some evidence that this attenuation bias indeed affects the estimates of the effect of PIN on board independence in our data; we discuss this issue in more detail later in the paper. Nevertheless, it is important to keep in mind that there is no reason to believe that measurement error in PIN can explain our findings; if anything, it makes it harder to detect any underlying relationship between the latent variables.

As an alternative to PIN, we also consider other price informativeness variables to corroborate our interpretation of the results. We first consider firm-specific stock return variation as a measure of price informativeness. Considerable research establishes that firm-specific stock return variation and price informativeness are closely related. French and Roll (1986) and Roll (1988) show that a significant portion of stock return variation is not explained by market movements. They suggest that firm-specific return variation measures the rate of private information incorporation into prices via trading. Although both uniformed trading and trading on the basis of public information can in principle explain firm-specific return variation, there is considerable empirical evidence supporting the use of firm-specific return variation as a measure of stock price informativeness and particularly of private information about firms. High levels of firm-specific return variation are associated with more efficient capital allocation (Durnev, Morck, and Yeung (2004)), and with more information about future earnings embedded in stock prices (Durnev, Morck, Yeung, and Zarowin (2003)).[11]

We estimate annual firm-specific return variation by regressing stock returns on the three factors from Fama-French. For each firm-year, firm-specific return variation is estimated by $1 - R^2$ from the regression:

$$r_{it} = \alpha_i + \beta_{1i} RM_t + \beta_{2i} SMB_t + \beta_{3i} HML_t + e_{it}, \tag{8}$$

[11] Cross-country patterns of firm-specific return variation also correspond to likely patterns of price informativeness. Morck et al. (2000) and Jin and Myers (2006) find high firm-specific stock return variation in developed markets, but low firm-specific return variation in emerging markets.

using daily return data, where r_{it} is the return of stock i in day t in excess of the risk-free rate, RM_t is the value-weighted excess local market return, SMB_t is the small-minus-big size factor return, and HML_t is the high-minus-low book-to-market factor return.[12] Given the bounded nature of R^2, we conduct our tests using a logistic transformation of $1 - R^2$:

$$\Psi = log\left(\frac{1-R^2}{R^2}\right) = log\left(\frac{\sigma_e^2}{\sigma^2 - \sigma_e^2}\right). \tag{9}$$

The variable Ψ measures firm-specific stock return variation relative to market-wide variation, or lack of synchronicity with the market.[13]

Finally, as an alternative measure of price informativeness or private information incorporated into stock prices, we use the illiquidity ratio of Amihud (2002). This measure is defined as the annual average of the daily ratio between a stock's absolute return and its dollar volume (multiplied by 10^6):

$$\text{ILLIQ} = \frac{1}{D_i}\sum_{t=1}^{D_i}\frac{|r_{it}|}{\text{VOLD}_{it}}, \tag{10}$$

where D_i is the annual number of valid observation days for stock i and VOLD_{it} is the dollar volume of stock i on day t. The illiquidity ratio gives the absolute (percentage) price change per dollar of daily trading volume and is a proxy for the price impact of order flow. The magnitude of the price impact should be a positive function of the perceived amount of informed trading on a stock (Kyle (1985)), although illiquidity will also reflect the inventory costs associated with trading a given order size, and thus it is also a noisy proxy for the private information content of prices.

[12] The daily returns for the small-minus-big (SMB) and high-minus-low (HML) factors are drawn from French's website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

[13] Alternative estimates of firm-specific return variation are provided by the market model that assumes $\beta_{2i} = \beta_{3i} = 0$ in equation (8) and by a two-factor (market and industry) model. We obtain similar findings using these alternative estimates.

3.3. Sample

We start with firms in the Investor Responsibility Research Center (IRRC) database between 1990 and 2001.[14] The IRRC database contains detailed information on governance and director characteristics for a large number of U.S. firms. We obtain board data for these firms from Compact Disclosure for the 1990-1995 period and from IRRC for the 1996-2001 period.[15] We exclude financial firms (SIC codes 6000-6999). We winsorize variables at the bottom and top 1% level.[16] After these adjustments the number of firms in the sample is 2,188. Next we merge the IRRC database with our main variable of price informativeness – the probability of information-based trading (PIN) for each firm-year, based on data from Easley et al. (2002).[17] The final sample contains 1,443 firms and a total of 9,447 firm-year observations.

We obtain financial and segment data from Compustat and stock returns and turnover data from CRSP. The governance index of Gompers et al. (2003) (GIM) and board attendance problems are available from the IRRC database. We obtain data on institutional holdings and the number of analysts covering each firm from Thomson CDA/Spectrum Institutional 13f Holdings and IBES. Blockholder ownership is based on data from Dlugosz, Fahlenbrach, Gompers, and Metrick (2006). Finally, we obtain additional director characteristics such as CEO ownership and tenure and number of board meetings from ExecuComp. Table 1 defines in detail the variables used in this study and describes their sources.

Table 2 presents descriptive statistics of our data. The median fraction of independent directors is 0.778. Board size ranges from 3 to 17 directors, with a median of 10 directors.

[14] Our sample ends in 2001 because PIN estimates are less reliable when short sales represent a significant fraction of the trading volume. In fact, PIN relies upon trade classification algorithms that fail to classify short sales correctly (Asquith, Oman, and Safaya (2007)).

[15] We thank Tina Yang for helping us with the Compact Disclosure board data. While IRRC provides detailed information on affiliation of directors, Compact Disclosure identifies only whether the director is an officer of the firm. Thus, board composition is only described in terms of the percentage of executive directors (insiders or officers) and non-executive directors on the board. In the robustness section, we report results using only IRRC data that are consistent with our primary findings.

[16] We obtain similar findings when we winsorize variables at the bottom and top 5% level.

[17] The estimates of PIN are obtained from Soeren Hvidkjaer's website: http://www.smith.umd.edu/faculty/hvidkjaer/data.htm.

There are on average 7.3 board meetings a year and 2.5% of the directors have attendance problems (attend less than 75% of board meetings). The mean PIN is 0.162 and the standard deviation is 0.056. These statistics are comparable to those reported in Easley et al. (2002). The mean firm-specific return variation ($1 - R^2$) from the three-factor model is 0.738, indicating that the Fama-French factors account only for 26.2% of total stock return variation. The mean illiquidity ratio (ILLIQ) is 0.165.

The median firm in our sample has a market capitalization of $1.1 billion, an age of 39.9 years, and a leverage ratio of 27.0%. The mean number of business segments is 2.2, the mean R&D expenditures-to-assets ratio is 1.9%, and the mean CEO ownership is 1.5%. The median firm has 10 takeover defenses (out of a maximum of 24). The mean total institutional ownership is 47.2% and the mean institutional blockholder ownership is 6.9%. These statistics are comparable to those found in similar studies, such as those of Gillan et al. (2006) and Coles et al. (2008).

4. Main Evidence

In this section we present our main results on the relationship between board independence and probability of informed trading (PIN). In the next sections, we provide additional evidence and perform several robustness checks.

Figure 1 presents a visual summary of the relationship between board independence and PIN. We first sort firms into quintile portfolios ranked by PIN. We then calculate the average board independence within each quintile portfolio of PIN. The main finding in this paper is clear from the figure: The average board independence for the lowest PIN (low market monitoring) portfolio (Q1) is greater than the one for the highest PIN (high market monitoring) portfolio (Q5). The low-PIN portfolio displays board independence of about 80%, while the corresponding figure for the high-PIN portfolio is about 70%. The difference between the two extreme quintile portfolios is highly statistically significant (t-statistic of

22.1). Moreover, all intermediate PIN portfolios present lower board independence than the low-PIN portfolio. Although the impact of PIN on board independence may appear economically small, we show later that it is actually quite large if compared to the analogous effects of other well-known determinants of board structure.

In Table 3, we present the outcome of several ordinary least squares (OLS) panel regressions, where the dependent variable y is a logistic transformation (or the log odds ratio) of the fraction of independent directors z (i.e. $y = \ln(z/1 - z)$). We use a logistic transformation because the fraction of independent directors is bounded between zero and one.[18] Our explanatory variable of interest is PIN. Table 3 presents the results from several specifications of the board independence regression, including one restricted to the PIN and one with the full set of control variables. We always include industry (two-digit SIC) and year dummy variables.[19] In our setting, cross-correlation and autocorrelation are likely to occur in our dependent variable. When this happens, conventional standard errors may be biased downwards. All reported t-statistics are therefore adjusted for heteroskedasticity and within-firm correlation using clustered standard errors. In addition, the inclusion of year dummies accounts for some forms of cross-sectional dependence (Petersen (2007)).

Column (1) presents the coefficients of a univariate regression between the fraction of independent directors and PIN. There is strong evidence of a negative and significant relationship. The PIN coefficient is -3.1376, with a high t-statistic of -13.60. This effect is economically significant: an increase in PIN from the 20th percentile to the 80th percentile (i.e., an increase in PIN from 0.11 to 0.21) predicts a decrease of roughly 6 percentage points in board independence (for a board with average independence).

Controlling for other firm characteristics does not change this result qualitatively. In column (2) we present estimates for a specification that does not include CEO ownership and tenure as controls because these variables are not available for the 1990-1991 period. The

[18] In the robustness section, we obtain similar results using the fraction of independent directors or the logarithm of the fraction of independent directors as dependent variables.

[19] We obtain similar results when we do not include industry or year dummies in the regression specification.

PIN coefficient is -1.9860 with a t-statistic of -7.76. In column (3) we add CEO ownership and tenure as controls, but the PIN estimate and t-statistic are barely affected. Overall, we find that the probability of informed trading displays a statistically and economically significant negative relationship with board independence.

With respect to the other explanatory variables, we find that leverage, firm age, and the number of business segments are all positively and significantly related to board independence. Firm size enters with a positive but insignificant coefficient (at the 5% level) in the majority of specifications. These findings are consistent with the scope of the operations hypothesis that more complex firms require more independent boards.

Consistent with the findings of Boone et al. (2007) and Coles et al. (2008), we find no statistically significant relationships between board independence and market-book ratio, R&D expenditures, return-on-assets, and stock return variance. The free cash flow variable also does not have a statistically significant point estimate. In contrast, we find that the coefficients of CEO ownership and tenure are both negative and statistically significant, which is consistent with the suggestion of Hermalin and Weisbach (1998) that board structure is influenced by the negotiations between CEOs and outside directors. The evidence indicates that board independence is negatively related to the degree of CEO influence.

Although the impact of PIN on board independence may appear small at first inspection, it is rather large if compared to the effects of other variables. Using the specification in column (2), a one-standard deviation increase in PIN reduces board independence by roughly 2.1 percentage points (at the averages of the data). If we perform the same experiment with the other variables that also enter significantly in the regression, we get effects of 1.4 percentage points for increasing leverage by one standard deviation, 1.4 percentage points for increasing firm age, and 1.3 percentage points for increasing the number of business segments by one standard deviation (always at the averages of the data). The bottom line here is that most variables that have been found to correlate with board independence can explain just a small part of the variation in board structures.

In columns (4) - (6) we control for the governance index (GIM), total institutional ownership, and institutional ownership concentration. The GIM coefficient is positive and statistically significant, which is consistent with the idea that board independence is higher in firms that are insulated from the market for corporate control. This finding is consistent with the empirical evidence of Gillan et al. (2006), who show that an independent board can act as a substitute for the market for corporate control. The institutional ownership variables are not significantly related to board independence.

So far we have treated PIN as a continuous variable. We now take an alternative approach and classify firms as either low PIN or high PIN. Specifically, we define a dummy variable that is equal to one for firm-years with PINs above the 80th percentile (Q5) and zero for firm-years with PINs below the 20th percentile (Q1). Notice that observations with intermediate values of PIN are not included in this regression. We re-estimate the board independence regressions in Table 3 using this dummy variable. The estimated coefficient on the PIN dummy variable measures the difference in board independence between firms with high and low PIN. This procedure tackles some possible of measurement errors problems in the PIN variable. If PIN is measured with error, focusing only on the extreme values of PIN might improve the precision of our estimates. Table 4 presents the results.

Column (1) presents the coefficients of a univariate regression of the fraction of independent directors on the PIN dummy variable (Q5 - Q1). There is strong evidence of a negative and significant relationship. The PIN dummy variable coefficient is -0.5193, with a high t-statistic of -13.08. This effect is economically significant: a move from the PIN bottom quintile (Q1) to the top quintile (Q5) predicts a decrease of roughly 10 percentage points in board independence (for a board with average independence). Controlling for other firm characteristics again does not change this result. In column (2), the PIN coefficient is -0.3404 with a t-statistic of -6.33.

The magnitude and significance of the effects suggest that, if anything, measurement errors in PIN seem to work against us finding any result. Despite the drop in the number

of observations, the statistical precision of our estimates is not affected. Furthermore, after eliminating the intermediate values of PIN from the regression, the point estimates of the effect of PIN on board independence are roughly increased by a factor of two.

In summary, we find that the probability of informed trading displays a statistically and economically significant negative relationship with board independence. This relationship is robust to the inclusion of many plausible variables that are likely to correlate with board independence.

5. Robustness

In this section, we check the robustness of our main results. We first present several alternative estimation methods, such as firm fixed effects and instrumental variables (2SLS). These alternative estimation methods address several concerns with our estimates, such as omitted variables, reverse causality, and measurement errors. We then present additional robustness checks such as sample variations and additional control variables. In the two final subsections, we present results using alternative measures of price informativeness and additional board-related variables.

5.1. Endogeneity: Omitted Variables and Reverse Causality

Endogeneity problems are ubiquitous in empirical research on corporate governance. In our setting, this problem is accentuated by recent findings showing that CEO decision-making power and board size both have direct effects on corporate performance, in particular the variability of stock returns (Adams, Almeida, and Ferreira (2005) and Cheng (2007)).[20] Furthermore, there could be other reasons for board structure and price informativeness to be jointly determined.

[20] We have already dealt with some of these issues in this paper. In order to be sure that our measure of price informativeness is not simply capturing the effect of stock return volatility, we have included the total stock return variance as a control variable in all specifications. More importantly, the effect of PIN is robust even when stock return variance is one of the controls.

We first address the potential endogeneity problems using firm fixed effects methods that control for unobserved sources of firm heterogeneity. Fixed-effects methods solve "joint determination" problems in which an unobserved time-invariant variable simultaneously determines both PIN and board independence. It is also equivalent to looking only at within-firm *changes* in PIN.

Columns (1) and (2) of Table 5 present the firm fixed effects estimates (with t-statistics adjusted for firm-level clustering). There is still evidence of a negative relation between board independence and PIN. In column (2), the estimate of the PIN coefficient is -0.5812 with a significant t-statistic of -2.62.

The fixed effects results go a long way towards dismissing omitted variables explanations as sources of endogeneity. Because only the effects of within-firm changes in board independence are taken into account, firm-specific omitted variables cannot explain the observed relationship between PIN and board independence. An issue here is whether there is enough variation in PIN and board independence over time so that one can estimate this relationship with precision. The short answer is yes; although t-statistics are lower, suggesting a lower precision in the estimates, they are still quite high by traditional standards.[21]

We also use instrumental variables as an alternative method to fixed effects, in order to address the potential endogeneity of PIN. Instrumental variables methods allow us to address omitted variables and reverse causality issues simultaneously. The caveat is that, unlike the fixed-effects method, it requires stronger assumptions that are usually not possible to test for. Under standard identification assumptions, we apply two-stage least squares (2SLS) methods to isolate the effect of PIN on board independence. To this end, we need a good instrument for PIN: a variable that is correlated with PIN (this assumption can be tested), but uncorrelated with board structure except indirectly through other independent variables. That is, the instrument should be a variable that can be "excluded" from the original list

[21] Interestingly, the idea that board structure does not change much over time may be more a myth than reality. Cicero, Wintoki, and Yang (2008) find that in the 1991-2003 period, two-thirds of the firms in their sample change either board size or independence during a two-year period. They also find that firms close 63% of the gap between their actual and target board independence over a two-year period.

of control variables without affecting the results. This last requirement cannot be tested by statistical methods; it is, in the end, an act of faith.

We use analyst coverage, share turnover, and S&P 500 membership as instruments. Easley, O'Hara, and Paperman (1998) suggest that analysts may serve to turn private information into public information and do not have significant firm-specific information. Analysts may attract additional uninformed order flow to a stock, an effect that would also reduce PIN. Empirical evidence seems to support a negative relation between price informativeness and analyst coverage (Piotroski and Roulstone (2004) and Chan and Hameed (2006)). Furthermore, Chen et al. (2007a) find a negative relation between PIN and the sensitivity of firm investment to stock prices, which suggests that information released by analysts and impounded in the stock price does not have much effect on managers' investment decisions. Share turnover is also likely to be negatively related to PIN, again consistent with the notion that stocks with greater trading activity tend to have more uninformed order flow (Easley et al. (2002)). We use as an additional instrument a dummy variable that takes the value of one if a stock included in the S&P 500 index as these firms tend to attract more investor attention. Thus, our instrumental variables have been previously found to be significantly correlated with price informativeness, but have never been used as explanatory variables in board independence regressions in previous studies.[22]

Columns (3) and (4) of Table 5 present the results of the first stage regressions that uses PIN as dependent variable. The results support the conclusion that analyst coverage and share turnover are negatively and significantly related to PIN, while S&P 500 membership is positively related to PIN. F-tests that the instruments can be excluded from the first stage regressions are strongly rejected (F-statistics are 13.7 and 9.8 in columns (3) and (4)). Thus, we conclude that our instruments are not only associated with PIN in the predicted direction, but also that our specifications do not appear to suffer from "weak instruments"

[22] Following Agarwal and O'Hara (2006), we also use lagged PIN as an instrument and obtain consistent results (not tabulated here). See Aslan, Easley, Hvidkjaer, and O'Hara (2006) for a discussion of alternative instruments for PIN.

concerns.[23]

Columns (5) and (6) present the 2SLS coefficients of the second-stage regression that uses board independence as the dependent variable. There is still evidence of a negative relation between board independence and PIN after taking into account the possibility that PIN is endogenous. Assuming that our instruments are valid, the evidence suggests the existence of a causal link from price informativeness to board structure. To assess the quality of the instruments formally, we also perform a Hansen $\mathcal{X}^2$-test of instrument orthogonality. This statistic jointly tests the null hypotheses of correct model specification and orthogonality between the instruments and the errors. Our instruments perform adequately in our tests (p-value is 0.63 and 0.57 in the specifications of columns (5) and (6) respectively), indicating that we cannot reject the null hypothesis of instrument suitability.

A final approach to address endogeneity concerns is to use lagged PIN as an explanatory variable. Columns (7) and (8) present the results of these estimations, confirming a negative relation between board independence and PIN. Although the finding that past PIN predicts future board structure cannot rule out all reverse causality stories, it addresses some of the most obvious ones.

Our conclusion here is twofold. Omitted variables are unlikely to explain the relationship between PIN and board independence: on top of our long list of control variables, firm fixed effects should take care of most invariant unobserved variables. We also find some evidence consistent with a causal effect from price informativeness to board independence. This evidence is less conclusive because the assumptions needed for our IV estimation are somewhat stronger than the ones needed for fixed effects. One has to keep in mind, however, that providing evidence for causality in one direction does not rule out causality running in both directions. We make no claim that board structure does not affect PIN as well, although we cannot test this hypothesis directly due to the lack of reasonable instruments for board independence.

[23] The S&P 500 dummy appears "weaker" than the other two instruments. Our results are practically the same if we exclude the S&P 500 dummy from the set of instruments.

5.2. Alternative Estimation Methods

All of our specifications so far have been estimated by least squares. Least squares methods are known to over-weight outliers. To address the concern that outliers may drive our core results, we winsorize financial ratios at the bottom and top 1% levels. In this subsection, we also use least-absolute deviation (median) regressions as an alternative means of addressing the difficulties associated with outliers. The results are presented in columns (1) and (2) of Table 6, and remain consistent with a negative relationship between board independence and PIN. As one can see from the point estimates, if anything, outliers seem to reduce the magnitude of the estimated effects.

The presence of time dependence and cross-sectional dependence in our data is also a potential concern. Our results so far account for cross-sectional and time dependence using industry and year dummies, firm fixed effects, and by computing firm-clustered standard errors. An alternative solution is to use the Fama-MacBeth procedure. Specifically, we estimate the relationship between board structure and PIN separately for each sample year and report the average of the yearly estimated coefficients.

Columns (3) and (4) of Table 6 present the results of the Fama-MacBeth procedure. The coefficients are qualitatively similar to those reported in Table 3. In column (3), the PIN coefficient is -1.1203, with a t-statistic of -7.71. The coefficients of the other firm characteristics are also consistent with the OLS panel regression estimates.

5.3. Additional Robustness Checks

This subsection discusses several additional robustness checks. These results appear in Table 7. With these results, we check whether our findings are robust to the sample period, to functional form assumptions, and to the inclusion of additional control variables. To save space, we only present the results for our most complete specification (column (5) in Table 3), but the results are also similar for other specifications.

Column (1) uses the 1996-2001 sample period, rather than 1990-2001. The 1996-2001

period corresponds to the period for which the IRRC directorship data are available. Therefore, column (1) uses only IRRC directorship data, rather than both Compact Disclosure (1990-1995) and IRRC data (1996-2001). This issue is a potential concern because Compact Disclosure classifies each director as either executive or non-executive, while IRRC uses a finer definition of independence. In addition, column (2) uses board data from Compact Disclosure for the whole sample period (1990-2001) as an alternative to the IRRC directorship data.

Column (3) uses the logarithm of board independence, rather than the logistic transformation, as the dependent variable. Column (4) uses the fraction of independent directors (i.e. restricted to $[0, 1]$) as the dependent variable. These confirm that our results are not driven by our particular functional form assumptions in the construction of the board independence variable.

Column (5) reports results after controlling for blockholder ownership, considering all types of blockholders rather than institutional investors only. Column (6) reports results after controlling for outside blockholders ownership rather than 13F institutional investors only. These blockholder ownership data are taken from Dlugosz et al. (2006) and cover the 1996-2001 sample period only.

Column (7) presents results that take into account product market competition. Shleifer and Vishny (1997) suggest that product market competition is one of the most effective mechanism to eliminate managerial inefficiency. We try to capture the competitive structure of an industry using the industry Herfindahl index, calculated as the sum of squared market shares of all firms in each industry (two-digit SIC) in each year. Industries with lower Herfindahl indices possess more competitive product markets. The industry Herfindahl index has indeed a positive coefficient but insignificant at the 5% level.

Column (8) presents results that control for earnings quality. Earnings quality is measured by the annual absolute value of firm-specific residuals from an industry regression of total accruals on lagged, contemporaneous, and leading cash flow from operations (Dechow

and Dichev (2002)). This variable is an *inverse* index of accounting quality, in that they increase in the magnitude of unexpected accruals. There is some evidence of a positive association between board independence and accounting quality.

Column (9) includes lag board size as an additional control variable following Boone et al. (2007) and Coles et al. (2008), Gillan et al. (2006).

Finally, in order to control for the potential differences in liquidity and governance requirements between stock exchanges, in column (10) we include a dummy variable that takes the value of one if a firm's stock is listed on the New York Stock Exchange (NYSE).

In all models, the estimated coefficient on the probability of informed trading remains negative and strongly significant. Our basic result is thus confirmed: more private information trading is strongly associated with less board independence, or in other words, with less need for board monitoring.

5.4. Alternative Measures of Price Informativeness

Is the empirical relationship between board independence and PIN driven by the private informational content of stock prices? In this section, we use two alternative measures of private information incorporated into prices as determinants of board structure. First, we use firm-specific stock return variation, or non-synchronicity of stock returns, as an alternative to the probability of informed trading in proxying for the intensity of private information incorporated into prices (Morck et al. (2000)). Firm-specific return variation is measured by the annual estimate of $1-R^2$ of the three-factor model of Fama-French using daily return data within each year as detailed in the data section. Although in principle non-synchronicity may also be due to trading on the basis of public information or noise trading, previous research has generally supported the view that non-synchronicity is mostly due to informed trading (Durnev et al. (2003) and Durnev et al. (2004)).

Secondly, we use the illiquidity ratio of Amihud (2002). This ratio gives the absolute (percentage) price change per dollar of daily trading volume and is a proxy for the price im-

pact of order flow. In theory, trading is linked to the quality or extent of private information (e.g., Blume, Easley, and O'Hara (1994)), and thus the price impact is a natural measure of private information flow. However, this measure is also likely to capture liquidity effects that are unrelated to information-based trading.[24]

We estimate board independence regressions similar to those in Table 3 using firm-specific return variation and the illiquidity ratio, as measures of private information incorporated into stock prices. We report the results in Table 8. Columns (1) and (2) show results for the regressions using the logistic transformation of firm-specific return variation (Ψ) as the measure of price informativeness. We find that the coefficients on Ψ are negative and statistically significant. Thus, board independence is lower in firms whose stock returns are less synchronized with the market.

Columns (3) and (4) in Table 8 present estimates using the annual illiquidity ratio (ILLIQ) as a measure of private information flow. ILLIQ is also negatively related to board independence, which supports the hypothesis that firms with a higher price impact of order flow (perhaps due to private information trading) have less independent boards.

In sum, the results using alternative proxies of price informativeness confirm our basic finding: Stock market monitoring and board monitoring appear to be substitutes.

5.5. Additional Board Monitoring Variables

It is natural to ask whether price informativeness also affects other variables that are likely to be associated with the monitoring intensity of the board. Here we focus on the number of board meetings and the fraction of directors with attendance problems as alternative proxies for the monitoring intensity of the board. We also analyze the impact of PIN on board size, although previous research has found that size does not have a one-to-one relation to monitoring intensity and is likely to be influenced by firms' need for board advice (Coles

[24] In a recent paper Bharath, Pasquariello, and Wu (2008) construct a firm-level index of information asymmetry based on four direct measures of information asymmetry (including PIN) and three broad measures of market liquidity (including the illiquidity ratio) to study capital structure decisions. The findings are robust to the inclusion of the broad measures of liquidity.

et al. (2008) and Linck et al. (2008)).

We first use the annual number of board meetings as the dependent variable. It has been argued that a board that meets more often is likely to be a better monitor (e.g., Vafeas (1999)). In Table 9, columns (1) and (2) present the estimates of OLS panel regressions in which the logarithm of the annual number of board meetings is the dependent variable. We find a negative relationship between the number of board meetings and PIN. If board meetings are seen as increasing in the board's monitoring intensity, this result is compatible with board monitoring and price informativeness being substitutes.

The Securities Exchange Act of 1934 requires corporations to list in their proxy statements the name of each director who attended fewer than 75% of the number of board meetings and board committees meetings on which he serves. A board with a higher fraction of directors with attendance problems is likely to be a poor monitor. Columns (3) and (4) present the estimates of regressions in which the annual fraction of directors with attendance problems is the dependent variable. We find a positive relationship between board attendance problems and PIN. Again, this result is compatible with board monitoring and price informativeness being substitutes.

Finally, columns (5) and (6) present the outcome of regressions in which the dependent variable is the logarithm of board size. We use the log transformation because board size is bounded below by zero. There is evidence of a negative and statistically significant relationship between board size and PIN. The statistical precision of such estimates are however much lower than the ones reported for the board independence regressions. Most of the other firm-level characteristics enter with their expected signs, and are usually consistent with the literature on board structure determinants (e.g., Boone et al. (2007) and Linck et al. (2008)).

It has been argued that larger boards are poor monitors (Lipton and Lorsch (1992) and Jensen (1993)). However, some also argue that larger boards are more diverse and produce more specialized advice to managers (Coles et al. (2008) and Linck et al. (2008)). Thus, although the evidence that we find is interesting, it is difficult to interpret. It should also be

noted that size and independence are positively correlated in the sample.

6. Interpreting the Relationship between Board Independence and the Probability of Informed Trading

In the previous sections, we have found strong evidence of a negative correlation between board independence and the probability of informed trading (PIN). Our findings suggest that when more information flows to the market (via trading on private information), firms tend to choose less independent boards. The interpretation is that when stock prices are more revealing, the stock market acts as a substitute for corporate boards in its monitoring role.

In this section, we present additional results that strengthen this interpretation, i.e. that price informativeness and board independence are *substitutes*.[25] We do so by focusing on the implications of our theoretical model. However, the empirical results are very intuitive and can also be understood without a direct reference to the model.

6.1. Takeover Defenses

If a firm adopts a large number of takeover defenses, it might become partially insulated from the market for corporate control (Field and Karpoff (2002) and Masulis, Wang, and Xie (2007)). In such cases, the takeover market cannot play an effective disciplinary role. Our hypothesis is that the trade-off between board independence and price informativeness is more relevant when there are few takeover defenses. This hypothesis is implied by Proposition 2.

We use the governance index of Gompers et al. (2003) (GIM) as a proxy for the number of takeover defenses a firm has in place. Columns (1) and (2) of Table 10 present the results of separate estimations on two subsets of the sample: firms whose GIM index is above 13

[25] Notice that this interpretation does not require us to take a stand on the direction of causality.

(column (1)) and firms whose GIM index is below 6 (column (2)).[26] Note that these two subsamples do not include all observations in the sample, but only the extreme cases.[27] We find that the relationship between board independence and PIN is negative and statistically significant for low GIM firms, but positive and statistically insignificant for high GIM firms. The difference between the two coefficients is statistically significant at the 5% level.

We conclude that the market for corporate control does have an important role to play in shaping the relation between board independence and price informativeness. Price informativeness can only substitute for the role of independent directors when the firm is open to the market for corporate control. This finding is also consistent with the evidence provided by Gillan et al. (2006), who show that if a disciplining takeover is more likely, then there is less need for board monitoring.

6.2. Institutional Ownership Concentration

If our theory is correct, shareholders should frequently intervene to change the board structure in response to exogenous changes in price informativeness.[28] Our theory is thus less plausible in dispersed ownership structures where shareholders have no incentives to engage in activism. That is, shareholders in dispersed ownership structures will face a high k, which is the marginal cost of changing board independence. Unlike individual investors, institutional investors (especially if they hold large blocks of stock) may have a clear incentive to maximize the firm value by changing the board structure whenever necessary. Thus, our hypothesis is that the trade-off between board independence and price informativeness is more relevant when there are large shareholders or when there is a higher concentration of institutional ownership. This is implied by Proposition 3. We use institutional ownership

[26] We choose to run separate regressions because it is easier to interpret the results. Results are similar if we implement our tests with interactions. To save space, we only present the results of our most complete specification (column (5) in Table III), but results are consistent for other specifications.

[27] Most firms have GIM indices that are clustered at the intermediate values.

[28] See Karpoff (2001) and Gillan and Starks (2007) for a summary of the evidence on shareholder activism and governance structure. The evidence suggests that active shareholders do affect governance structures, although the effect of activism on firm performance is not clear cut.

concentration as a (inverse) proxy for k.

Columns (3) and (4) of Table 5 present results by splitting the sample into firms with more or less concentrated institutional ownership: firms whose institutional Herfindahl index is above the 80th percentile (column (3)) and firms whose institutional Herfindahl index is below the 20th percentile (column (4)). We find a negative and statistically significant relationship between board independence and PIN for the high institutional ownership concentration sample, but this relationship is statistically insignificant for firms with a low concentration of institutional ownership. In other words, the probability of informed trading is only (robustly) negatively related to board independence for those firms with a high concentration of institutional ownership. The difference between the two coefficients is statistically significant at the 5% level.[29]

These results suggest that price informativeness can only be an effective substitute for internal monitoring (by the board) when large institutional shareholders supervise the board themselves. Without a substantial concentration of institutional ownership, perhaps the board only plays a minor role. In such cases, it would be natural to find a weak or no relationship between board independence and stock price informativeness.

6.3. Firm-Specific Knowledge

When firm-specific knowledge is important, a board that is too independent may fail to obtain crucial information. Perhaps there are few informed insiders (Raheja (2005)), or perhaps the CEO refuses to communicate with the board (Adams and Ferreira (2007)). We thus expect that costs associated with the acquisition of firm-specific knowledge may affect the relationship between board structure and price informativeness. Specifically, if stock markets can substitute for corporate boards as monitors of management, we expect to find a stronger negative relationship between board independence and price informativeness when firm-specific knowledge is less important. The idea is simply that CEOs and inside

[29] We obtain similar findings when we split the sample using the institutional blockholder ownership variable.

directors possess more firm-specific knowledge than outside directors (Fama and Jensen (1983)). Consequently, the trade-off between board independence and price informativeness becomes less effective when this type of knowledge is more important. This hypothesis is formally derived in Proposition 4.

Measuring the importance of firm-specific knowledge is a difficult task. Following Coles et al. (2008), we use R&D expenditures as a proxy for the importance of firm-specific knowledge. Firm-specific knowledge is harder for outsiders to acquire in firms with high levels of R&D expenditure. If the kind of information that market prices convey cannot substitute for the knowledge that insiders possess, the substitution effect should be weaker for firms with high R&D.

Columns (5) and (6) in Table 5 present the results of separate regressions for two subsamples that differ from each other according to their R&D expenditures. In one set of firms, the ratio of R&D expenditures to assets is above the 80th percentile (column (5)); all other firms (low R&D and firm-specific knowledge) are placed in the other category (column (6)).[30] The evidence shows that the relationship between board independence and PIN is negative and statistically significant in low R&D firms, but statistically insignificant in high R&D firms. The difference between the two coefficients is statistically significant at the 5% level.

This evidence is consistent with the hypothesis that when firm-specific knowledge is less important, the private information revealed by stock prices can substitute for the monitoring role of corporate boards. No such a trade-off is possible, however, when firm-specific knowledge is important.

[30] The 80th percentile actually corresponds to the median for firms with positive R&D expenditures as only 40% of the observations have positive R&D. The findings are similar if we use the 75th percentile as the cut-off.

6.4. Pay-Performance Sensitivity

Finally, we also estimate the impact of PIN on board independence after splitting the sample according to the intensity of equity-based pay for the CEO. Executive compensation plans can help to align the interests of managers with those of shareholders. Although our model does not have any prediction with respect to equity-based incentives, previous models on the monitoring role of stock prices (Holmstrom and Tirole (1993)) have focused on the role of executive compensation as the main mechanism through which stock prices discipline managers. Thus, we expect to find a stronger relationship between price informativeness and board independence in firms in which pay-performance sensitivities (PPS) of CEO compensation contracts is high. PPS is defined as the change in dollar value of a CEO's holdings of stock options per $1,000 change in the firm's market value of equity.

Columns (7) and (8) of Table 10 present the results of separate regressions for two subsamples that differ from each other according to their CEO pay-performance sensitivities (PPS): firms whose PPS is above the 80th percentile (column (7)) and firms whose PPS is below the 20th percentile (column (8)). We find a negative and statistically significant relationship between board independence and PIN for the high PPS sample, but this relationship is statistically insignificant for firms with low PPS. The difference between the two coefficients is statistically significant at the 5% level.

These results suggest that price informativeness can only be an effective substitute for internal monitoring (by the board) when managerial incentives are closely tied to the shareholder value.

7. Conclusion

In this paper, we add a new and important element to the list of determinants of board structure − price informativeness. We develop and test the hypothesis that the amount of private information incorporated into stock prices affects the structure of corporate boards,

in particular board independence.

We find robust empirical evidence that stock price informativeness, as measured by the probability of informed trading (PIN) and other proxies, is negatively related to board independence. The correlation between price informativeness and board independence is at least as strong − in both economic and statistical senses − as the ones between board independence and other firm-level variables that have been documented in the literature on corporate boards. Given our long list of control variables and the use of fixed-effects methods, it is unlikely that price informativeness is capturing the effects of omitted variables.

Consistent with the theory that we propose, the negative relationship between price informativeness and board monitoring is particularly strong for firms with few takeover defenses. We also find that ownership concentration seems to be a condition for the existence of a trade-off between board monitoring and price informativeness. Finally, the negative relationship between board independence and price informativeness is particularly strong for firms with less firm-specific knowledge and more pay-perfomance sensitivity in CEO compensation.

One possible interpretation for our results suggests that if stock prices are informative, stock markets are able to perform a *monitoring role* like that normally associated with the board of directors. Our results are thus consistent with the hypothesis that board monitoring and stock market monitoring are *substitutes*. The evidence that more informative prices are associated with a lower degree of board independence, fewer board meetings, weaker attendance at board meetings, and smaller board size all point in a similar direction: Firms with more informative stock prices require less demanding board structures.

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Table 1
Definitions of Variables

Variable	Definition
Fraction of independent directors	Ratio of number of independent directors to board size (1990-1995 data from Compact Disclosure and 1996-2001 data from IRRC).
Board size	Number of board members (1990-1995 data from Compact Disclosure and 1996-2001 data from IRRC).
Number of board meetings	Number of board meetings by year (EXECUCOMP).
Board attendance problems	Ratio of directors that attended less than 75% of board/committee meetings to board size (IRRC).
Probability of informed trading	Probability of information-based trading (PIN) of Easley et al. (2002).
Probability of informed trading dummy (Q5 - Q1)	Dummy variable that takes the value of one if a firm-year is in the top (Q5) PIN quintile and zero in the bottom (Q1) PIN quintile.
Firm-specific return variation	$1 - R^2$ of the Fama-French three-factor regression model using daily stock returns.
Illiquidity	Average daily ratio of a stock's absolute return by the dollar volume (Amihud (2002)).
Firm size	Market capitalization in $ millions (COMPUSTAT: item 25 $\times$ item 199).
Leverage	Ratio of total debt to total assets (COMPUSTAT: (item 9 + item 34) / item 6).
Firm age	Number of years since the stock inclusion in the CRSP database.
Number of business segments	Number of business segments in which a firm operates (COMPUSTAT).
Market-to-book	Ratio of market value of equity to book value of equity (COMPUSTAT: item 25 $\times$ item 199 / item 60).
R&D expenditures	Ratio of R&D expenditures by total assets (COMPUSTAT: item 46 / item 6).
Stock return variance	Stock return variance (annualized) estimated with daily stock returns (CRSP).
Free cash flow	Ratio of operating income before depreciation minus capital expenditures by total assets (COMPUSTAT: (item 13 $-$ item 128) / item 6).
Return-on-assets	Ratio of operating income before depreciation to total assets (COMPUSTAT: item 13 / item 6).
CEO ownership	Number of shares held by the CEO divided by number of shares outstanding (EXECUCOMP).
CEO tenure	Number of years since the director became CEO (EXECUCOMP).
Governance index (GIM)	Governance index of Gompers et al. (2003), which is based on 24 antitakeover provisions (IRRC).
Institutional ownership	Number of shares held by institutions divided by the number of shares outstanding (Thomson 13f Holdings).
Institutional Herfindahl	Institutional Herfindahl index calculated using institutional ownership (Thomson 13f Holdings).
Institutional blockholder ownership	Number of shares held by the firm's largest institution with at least 5% of shares divided by the number of shares outstanding (Thomson 13f Holdings)
Blockholder ownership	Number of shares held by all blockholders divided by the number of shares outstanding (Dlugosz et al. (2006)).
Outside blockholder ownership	Number of shares held by outside blockholders divided by the number of shares outstanding (Dlugosz et al. (2006)).
Industry Herfindahl	Industry Herfindahl index calculated as the sum of squared market shares of firms' sales (COMPUSTAT: item 12) in a firm's industry (two-digit SIC).
CEO pay-performance sensitivity (PPS)	Change in the dollar value of a CEO's holdings of stock options per $1,000 change in firm's market value of equity.
Earnings quality	Absolute value of firm-specific residuals from an annual industry regression (two-digit SIC) of total accruals on lagged, contemporaneous, and leading cash flow from operations; variables scaled by total assets.
NYSE dummy	Dummy variable that takes the value of one if a firm's stock is traded on the NYSE, zero otherwise (CRSP).
Number of analysts	Number of analysts covering a firm (IBES).
Share turnover	Number of shares traded divided by the number of shares outstanding (CRSP).
S&P 500 membership	Dummy variable that takes the value of one if a firm is a member of the S&P 500 index, zero otherwise (CRSP).

Table 2
Summary Statistics

This table reports the mean, median, standard deviation, minimum, maximum, and number of observations for each variable. The variables are defined in Table 1. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999).

	Mean	Median	Std Dev	Min	Max	*N*
Fraction of independent directors	0.753	0.778	0.135	0.100	0.955	9,447
Board size	9.819	10.000	2.798	3.000	17.000	9,447
Number of board meetings	7.282	7.000	2.689	3.000	16.000	6,233
Board attendance problems	0.025	0.000	0.054	0.000	0.250	4,922
Probability of informed trading	0.162	0.154	0.056	0.068	0.357	9,447
Firm-specific return variation	0.738	0.756	0.101	0.424	0.917	14,661
Illiquidity	0.165	0.009	0.706	0.000	6.881	13,957
Firm size	3,819	1,079	7,989	14	51,179	9,236
Leverage	0.274	0.270	0.176	0.000	0.919	9,228
Firm age	32.026	39.917	15.758	1.167	50.917	9,447
Number of business segments	2.158	1.000	1.461	1.000	6.000	9,447
Market-to-book	2.861	2.063	2.979	0.528	23.957	9,236
R&D expenditures	0.019	0.000	0.038	0.000	0.368	8,774
Stock return variance	0.173	0.113	0.206	0.012	2.189	9,447
Free cash flow	0.076	0.079	0.090	-0.447	0.332	9,086
Return-on-assets	0.145	0.141	0.082	-0.352	0.409	9,241
CEO ownership	0.014	0.001	0.042	0.000	0.251	9,447
CEO tenure	4.257	1.000	6.318	0.000	27.000	9,447
Governance index (GIM)	9.433	10.000	2.746	3.000	15.000	8,404
Institutional ownership	0.472	0.524	0.260	0.000	0.914	9,447
Institutional Herfindahl	0.067	0.050	0.073	0.000	0.477	9,447
Institutional blockholder ownership	0.069	0.070	0.063	0.000	0.282	9,447
Blockholder ownership	0.192	0.162	0.184	0.000	0.663	5,235
Outside blockholder ownership	0.136	0.096	0.148	0.000	0.557	5,235
Industry Herfindahl	0.128	0.097	0.120	0.026	1.000	9,447
CEO pay-performance sensitivity (PPS)	10.774	6.557	12.795	0.298	82.089	4,761
Earnings quality	0.100	0.056	0.127	0.005	0.578	7,783
NYSE dummy	0.881	1.000	0.323	0.000	1.000	9,295
Number of analysts	8.322	6.000	8.205	0.000	31.000	9,447
Share turnover	0.909	0.727	0.699	0.068	8.136	9,447
S&P 500 membership	0.266	0.000	0.442	0.000	1.000	9,294

Table 3
Board Independence and Probability of Informed Trading

Estimates of OLS panel regressions of the logistic transformed fraction of independent directors are shown. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
Probability of informed trading	-3.1376	-1.9860	-1.8604	-1.5294	-1.5383	-1.5299
	(-13.60)	(-7.76)	(-6.81)	(-5.08)	(-5.15)	(-5.08)
Firm size (log)		0.0259	0.0193	0.0226	0.0224	0.0226
		(1.79)	(1.34)	(1.48)	(1.44)	(1.47)
Leverage		0.4392	0.3749	0.3177	0.3214	0.3214
		(4.33)	(3.81)	(3.01)	(3.01)	(3.01)
Firm age (log)		0.1566	0.1521	0.1030	0.1063	0.1068
		(7.05)	(7.01)	(3.98)	(4.11)	(4.12)
Number of business segments (log)		0.0997	0.1059	0.0854	0.0854	0.0860
		(4.14)	(4.62)	(3.64)	(3.65)	(3.67)
Market-to-book (log)		0.0066	0.0136	0.0164	0.0171	0.0178
		(0.28)	(0.56)	(0.64)	(0.67)	(0.70)
R&D expenditures		0.1626	-0.1125	-0.1309	-0.1113	-0.1119
		(0.40)	(-0.29)	(-0.30)	(-0.25)	(-0.26)
Stock return variance		-0.0723	-0.0453	-0.0246	-0.0292	-0.0240
		(-1.27)	(-0.76)	(-0.40)	(-0.47)	(-0.39)
Free cash flow		0.3023	0.3778	0.1244	0.1178	0.1204
		(1.05)	(1.34)	(0.41)	(0.39)	(0.40)
Return-on-assets		-0.5283	-0.5507	-0.3896	-0.3930	-0.3977
		(-1.56)	(-1.67)	(-1.13)	(-1.14)	(-1.15)
CEO ownership			-2.3059	-1.8691	-1.8684	-1.8792
			(-6.54)	(-4.91)	(-4.89)	(-4.95)
CEO tenure			-0.0044	-0.0058	-0.0059	-0.0058
			(-1.73)	(-2.24)	(-2.30)	(-2.28)
Governance index (GIM)				0.0400	0.0402	0.0399
				(6.03)	(6.03)	(5.97)
Institutional ownership					0.0755	0.0390
					(1.25)	(0.53)
Institutional Herfindahl					0.1893	
					(0.74)	
Institutional blockholder ownership						0.2929
						(0.96)
R^2	0.082	0.144	0.166	0.163	0.164	0.164
N	9,447	8,610	7,504	6,740	6,740	6,740

Table 4
Board Independence and Probability of Informed Trading Quintiles

Estimates of OLS panel regressions of the logistic transformed fraction of independent directors are shown. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
Probability of informed trading dummy (Q5 − Q1)	-0.5193	-0.3404	-0.3399	-0.2708	-0.2746	-0.2702
	(-13.08)	(-6.33)	(-6.12)	(-4.59)	(-4.66)	(-4.57)
Firm size (log)		0.0187	0.0115	0.0205	0.0211	0.0203
		(1.06)	(0.65)	(1.09)	(1.11)	(1.08)
Leverage		0.3937	0.3896	0.3286	0.3319	0.3328
		(3.25)	(3.07)	(2.42)	(2.42)	(2.43)
Firm age (log)		0.1965	0.1881	0.1518	0.1572	0.1576
		(7.25)	(6.76)	(4.49)	(4.60)	(4.61)
Number of business segments (log)		0.0707	0.0683	0.0418	0.0413	0.0418
		(2.48)	(2.48)	(1.53)	(1.51)	(1.53)
Market-to-book (log)		0.0084	0.0124	0.0103	0.0100	0.0112
		(0.29)	(0.42)	(0.32)	(0.32)	(0.35)
R&D expenditures		0.4071	0.3513	0.5496	0.5686	0.5564
		(0.73)	(0.64)	(0.89)	(0.92)	(0.90)
Stock return variance		-0.0606	0.0069	0.0329	0.0243	0.0302
		(-0.77)	(0.08)	(0.33)	(0.25)	(0.31)
Free cash flow		0.3559	0.4728	0.1206	0.1139	0.1219
		(1.06)	(1.36)	(0.31)	(0.30)	(0.32)
Return-on-assets		-0.6032	-0.8197	-0.6705	-0.6639	-0.6833
		(-1.58)	(-2.05)	(-1.61)	(-1.58)	(-1.64)
CEO ownership			-1.9879	-1.6861	-1.7101	-1.7090
			(-3.74)	(-3.03)	(-3.06)	(-3.06)
CEO tenure			-0.0041	-0.0066	-0.0066	-0.0066
			(-1.31)	(-2.13)	(-2.15)	(-2.15)
Governance index (GIM)				0.0396	0.0394	0.0389
				(4.93)	(4.88)	(4.83)
Institutional ownership					0.0694	0.0441
					(0.89)	(0.46)
Institutional Herfindahl					0.2539	
					(0.87)	
Institutional blockholder ownership						0.2308
						(0.58)
R^2	0.137	0.199	0.204	0.186	0.188	0.187
N	3,815	3,471	3,044	2,735	2,735	2,735

Table 5
Board Independence and Probability of Informed Trading: Endogeneity

Estimates of regressions of the logistic transformed fraction of independent directors using alternative estimation methods are shown. Columns (1) and (2) present estimates of panel regressions with firm fixed effects. The two-stage least squares (2SLS) panel regression uses analyst coverage, share turnover, and S&P 500 membership as instruments for PIN. Columns (3) and (4) present first stage regression estimates with PIN as dependent variable. Columns (5) and (6) present second stage regression estimates with the logistic transformed fraction of independent directors as dependent variable. Columns (7) and (8) present estimates of regressions using lagged PIN as explanatory variable. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Firm fixed effects		Two-stage least squares (2SLS)				Lag PIN	
			First stage	First stage	Second stage	Second stage		
Probability of informed trading (PIN)	-0.6940	-0.5812			-8.8139	-10.3296	-1.6905	-1.3691
	(-3.58)	(-2.62)			(-2.70)	(-2.30)	(-6.47)	(-4.76)
Firm size (log)	0.0738	0.0683	-0.0232	-0.0221	-0.1375	-0.1736	0.0297	0.0258
	(3.02)	(2.60)	(34.67)	(32.52)	(-1.75)	(-1.70)	(2.08)	(1.71)
Leverage	0.3394	0.2417	-0.0154	-0.0171	0.3395	0.2351	0.4344	0.3130
	(3.14)	(2.05)	(3.42)	(3.77)	(3.16)	(1.98)	(4.18)	(2.89)
Firm age (log)	0.4413	0.6101	-0.0045	-0.0044	0.1303	0.1198	0.1595	0.1042
	(8.09)	(6.11)	(4.92)	(4.73)	(5.02)	(4.12)	(6.97)	(3.99)
Number of business segments (log)	0.0150	0.0118	-0.0056	-0.0056	0.0645	0.0614	0.1024	0.0853
	(0.77)	(0.60)	(5.77)	(5.78)	(2.15)	(1.83)	(4.27)	(3.61)
Market-to-book (log)	0.0098	-0.0120	0.0042	0.0055	0.0370	0.0620	0.0080	0.0194
	(0.44)	(-0.53)	(3.64)	(4.75)	(1.43)	(1.87)	(0.32)	(0.76)
R&D expenditures	-0.4203	-0.5590	0.0191	0.0163	0.2163	-0.0500	0.0910	-0.2403
	(-0.88)	(-0.83)	(1.00)	(0.85)	(0.51)	(-0.12)	(0.22)	(-0.54)
Stock return variance	0.2085	0.1374	-0.0277	-0.0275	-0.3181	-0.3338	-0.0746	-0.0339
	(3.91)	(2.10)	(8.10)	(7.83)	(-2.58)	(-2.11)	(-1.23)	(-0.54)
Free cash flow	-0.1143	-0.2661	-0.0135	-0.0103	0.2832	0.3591	0.2094	0.0630
	(-0.59)	(-1.06)	(1.38)	(1.04)	(0.98)	(1.26)	(0.69)	(0.21)
Return-on-assets	0.0063	0.1705	0.0091	-0.0002	-0.5447	-0.6301	-0.4355	-0.3423
	(0.02)	(0.55)	(0.75)	(0.01)	(-1.60)	(-1.85)	(-1.23)	(-0.98)
CEO ownership		0.4657		0.0283		-2.0518		-1.8711
		(1.23)		(1.68)		(-4.84)		(-4.86)
CEO tenure		-0.0051		-0.0004		-0.0085		-0.0061
		(-2.34)		(4.72)		(-2.54)		(-2.35)
Governance index (GIM)		0.0416		-0.0007		0.0309		0.0397
		(3.53)		(2.78)		(2.65)		(5.94)
Institutional ownership		0.0338		-0.0085		-0.0460		0.0837
		(0.42)		(2.81)		(-0.35)		(1.37)
Institutional Herfindahl		0.2565		0.0657		1.0457		0.1218
		(1.61)		(5.34)		(1.23)		(0.48)
Number of analysts			-0.0013	-0.0013				
			(2.10)	(2.16)				
Share turnover			-0.0059	-0.0042				
			(5.37)	(3.98)				
S&P 500 membership			0.0034	0.0022				
			(2.12)	(1.35)				
R^2	0.095	0.088	0.462	0.449			0.139	0.161
N	8,610	6,740	8,610	6,740	8,610	6,740	7,927	6,658

Table 6
Board Independence and Probability of Informed Trading: Alternative Estimation Methods

Estimates of regressions of the logistic transformed fraction of independent directors using alternative estimation methods are shown. Columns (1) and (2) present estimates of median (least-absolute deviation) panel regression. Columns (3) and (4) present estimates of cross-sectional regressions using the Fama-MacBeth procedure. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions in columns (1) and (2) include industry and year dummies. Robust t-statistics adjusted for firm-level clustering (columns (1) and (2)) are in parentheses .

	(1)	(2)	(3)	(4)
	Median regression		Fama-MacBeth	
Probability of informed trading (PIN)	-2.2345	-1.8275	-1.1203	-0.8144
	(-9.36)	(-6.14)	(-7.71)	(-3.37)
Firm size (log)	0.0115	-0.0024	0.0175	0.0126
	(1.17)	(-0.20)	(2.74)	(1.60)
Leverage	0.5376	0.3759	0.4690	0.3486
	(9.04)	(5.38)	(13.19)	(7.78)
Firm age (log)	0.1736	0.1252	0.1562	0.1042
	(12.97)	(6.87)	(13.55)	(11.59)
Number of business segments (log)	0.0766	0.0638	0.0926	0.0798
	(4.54)	(3.41)	(8.70)	(6.00)
Market-to-book (log)	0.0137	0.0238	-0.0078	0.0237
	(0.79)	(1.17)	(-0.45)	(1.59)
R&D expenditures	-0.1276	-0.2050	0.7357	0.4601
	(-0.46)	(-0.61)	(4.35)	(4.53)
Stock return variance	-0.0068	-0.0229	-0.3434	-0.4132
	(-0.13)	(-0.36)	(-4.57)	(-3.69)
Free cash flow	0.0793	0.0606	-0.0061	-0.2502
	(0.45)	(0.29)	(-0.05)	(-1.38)
Return-on-assets	-0.3578	-0.5427	-0.3193	-0.2341
	(-1.78)	(-2.26)	(-2.33)	(-1.83)
CEO ownership		-2.0375		-1.9228
		(-7.31)		(-6.79)
CEO tenure		-0.0066		-0.0063
		(-3.60)		(-4.97)
Governance index (GIM)		0.0359		0.0393
		(8.03)		(18.56)
Institutional ownership		0.0865		-0.0046
		(1.88)		(-0.12)
Institutional Herfindahl		0.0661		-0.0798
		(0.36)		(-0.41)
R^2			0.105	0.156
N	8,610	6,740	8,610	6,740

Table 7
Board Independence and Probability of Informed Trading: Additional Robustness Checks

Estimates of OLS panel regressions of the logistic transformed fraction of independent directors, the log fraction of independent directors (column (3)), and the fraction of independent directors (column (4)) are shown. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	IRRC 1996-2001	Compact Disclosure	Board indep. (log)	Board indep.	All blockholders	Outside blockholders	Industry Herfindahl	Earnings quality	Board size	NYSE
Probability of informed trading (PIN)	-0.9069	-0.8999	-0.3606	-0.1909	-0.8460	-0.9136	-1.5469	-1.2802	-1.5258	-1.4974
	(-2.52)	(-3.17)	(-4.06)	(-2.86)	(-2.30)	(-2.47)	(-5.18)	(-4.43)	(-4.94)	(-5.00)
Firm size (log)	0.0201	0.0228	0.0054	0.0055	0.0190	0.0223	0.0214	0.0254	0.0053	0.0190
	(1.21)	(1.47)	(1.24)	(1.66)	(1.15)	(1.35)	(1.38)	(1.57)	(0.31)	(1.24)
Leverage	0.2787	0.3029	0.0879	0.0735	0.2771	0.2737	0.3264	0.4203	0.2973	0.3268
	(2.52)	(2.85)	(2.75)	(3.24)	(2.51)	(2.47)	(3.06)	(3.85)	(2.63)	(3.06)
Firm age (log)	0.1123	0.0957	0.0205	0.0138	0.1128	0.1204	0.1066	0.1079	0.1026	0.1094
	(4.01)	(3.62)	(2.59)	(2.46)	(3.96)	(4.21)	(4.13)	(3.81)	(3.60)	(4.26)
Number of business segments (log)	0.0684	0.1082	0.0258	0.0127	0.0683	0.0675	0.0849	0.1098	0.0988	0.0842
	(2.93)	(4.30)	(4.18)	(2.55)	(2.91)	(2.88)	(3.63)	(4.38)	(4.08)	(3.60)
Market-to-book (log)	0.0078	0.0434	0.0081	0.0059	0.0074	0.0098	0.0185	0.0102	0.0261	0.0184
	(0.28)	(1.78)	(1.17)	(1.14)	(0.26)	(0.34)	(0.73)	(0.40)	(0.98)	(0.72)
R&D expenditures	0.2971	0.2050	-0.0451	-0.0270	0.2939	0.2938	-0.0779	-0.0544	0.1237	-0.0815
	(0.64)	(0.45)	(-0.35)	(-0.28)	(0.63)	(0.63)	(-0.18)	(-0.12)	(0.29)	(-0.19)
Stock return variance	-0.0925	-0.0869	0.0227	-0.0071	-0.0856	-0.0903	-0.0325	-0.0031	0.0320	-0.0055
	(-1.44)	(-1.35)	(1.30)	(-0.50)	(-1.34)	(-1.42)	(-0.52)	(-0.04)	(0.48)	(-0.09)
Free cash flow	0.2321	-0.2222	0.0303	-0.0206	0.2401	0.2377	0.1363	0.0227	0.0833	0.1184
	(0.77)	(-0.72)	(0.32)	(-0.31)	(0.79)	(0.79)	(0.45)	(0.07)	(0.27)	(0.39)
Return-on-assets	-0.3563	-0.1136	-0.0615	-0.0117	-0.3836	-0.3784	-0.4132	-0.1770	-0.3244	-0.4480
	(-1.03)	(-0.32)	(-0.57)	(-0.15)	(-1.11)	(-1.09)	(-1.20)	(-0.47)	(-0.92)	(-1.30)
CEO ownership	-2.0585	-1.7194	-0.5215	-0.3082	-2.0476	-1.9487	-1.8687	-1.7319	-1.6205	-1.8471
	(-4.36)	(-4.68)	(-4.10)	(-3.74)	(-4.34)	(-4.12)	(-4.90)	(-3.83)	(-4.28)	(-4.87)
CEO tenure	-0.0092	-0.0006	-0.0012	-0.0009	-0.0092	-0.0091	-0.0059	-0.0060	-0.0059	-0.0061
	(-3.05)	(-0.24)	(-1.47)	(-1.64)	(-3.08)	(-3.06)	(-2.29)	(-2.20)	(-2.27)	(-2.38)
Governance index (GIM)	0.0392	0.0512	0.0113	0.0071	0.0386	0.0377	0.0400	0.0416	0.0396	0.0400
	(5.14)	(7.64)	(5.81)	(4.95)	(5.09)	(4.93)	(6.01)	(5.90)	(5.69)	(6.05)
Institutional ownership	0.0120	0.0756	0.0278	0.0149			0.0741	0.1257	0.1189	0.0677
	(0.19)	(1.21)	(1.81)	(1.14)			(1.22)	(1.96)	(1.85)	(1.11)
Institutional Herfindahl	0.2839	0.1286	0.0557	0.0655			0.1868	0.3304	0.1748	0.1905
	(1.15)	(0.49)	(0.75)	(1.31)			(0.73)	(1.02)	(0.67)	(0.74)
Blockholders ownership					0.0195					
					(0.20)					
Outside blockholders ownership						0.3024				
						(2.73)				
Industry Herfindahl							0.1286			
							(1.02)			
Earnings quality								-0.1665		
								(-1.99)		
Board size (lag)									0.0172	
									(2.14)	
NYSE dummy										0.1045
										(1.82)
R^2	0.169	0.153	0.143	0.088	0.168	0.172	0.164	0.185	0.170	0.165
N	4,504	6,029	6,896	7,034	4,504	4,504	6,740	5,710	6,175	6,740

Table 8
Board Independence and Alternative Measures of Price Informativeness

Estimates of OLS panel regressions of alternative price informativeness measures are shown. Columns (1) and (2) use the logistic transformed relative firm-specific return variation as dependent variable. Columns (3) and (4) use the logarithm of the illiquidity measure of Amihud (2002). Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)
Firm-specific return variation (logistic)	-0.0877	-0.0699		
	(-4.88)	(-3.74)		
Illiquidity (log)			-0.0829	-0.0722
			(-6.96)	(-4.46)
Firm size (log)	0.0748	0.0549	-0.0208	-0.0285
	(7.23)	(4.83)	(-1.07)	(-1.25)
Leverage	0.2839	0.1913	0.3264	0.2227
	(3.79)	(2.29)	(4.46)	(2.72)
Firm age (log)	0.1417	0.0942	0.1500	0.1059
	(8.64)	(4.68)	(9.22)	(5.19)
Number of business segments (log)	0.0996	0.0676	0.1111	0.0825
	(4.92)	(3.29)	(5.42)	(4.10)
Market-to-book (log)	0.0137	0.0292	-0.0262	0.0063
	(0.85)	(1.60)	(-1.40)	(0.30)
R&D expenditures	0.9549	0.6470	0.6232	0.3124
	(4.47)	(2.58)	(2.85)	(1.23)
Stock return variance			-0.0266	-0.0209
			(-0.83)	(-0.57)
Free cash flow	0.4644	0.2125	0.6486	0.4124
	(2.09)	(0.88)	(2.94)	(1.70)
Return-on-assets	-0.9283	-0.5958	-1.0350	-0.7580
	(-3.80)	(-2.28)	(-4.17)	(-2.85)
CEO ownership		-1.9371		-1.9263
		(-6.52)		(-6.28)
CEO tenure		-0.0048		-0.0056
		(-2.26)		(-2.63)
Governance index (GIM)		0.0404		0.0394
		(7.49)		(7.29)
Institutional ownership		0.0890		0.0504
		(1.76)		(0.97)
Institutional Herfindahl		0.0600		0.3010
		(0.29)		(1.41)
R^2	0.151	0.159	0.159	0.162
N	11,755	9,460	12,964	9,168

Table 9
Additional Board Monitoring Variables and Probability of Informed Trading

Estimates of OLS panel regressions of the logarithm of the number of board meetings, the fraction of directors with board attendance problems, and the logarithm of board size are shown. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of board meetings (log)		Board attendance problems		Board size (log)	
Probability of informed trading	-0.3878	-0.3773	0.0477	0.0500	-0.2942	-0.2514
	(-2.08)	(-1.99)	(2.11)	(2.12)	(-2.51)	(-1.97)
Firm size (log)	0.0415	0.0390	0.0018	0.0018	0.0844	0.0870
	(5.06)	(4.57)	(2.30)	(2.22)	(16.84)	(15.61)
Leverage	0.0965	0.0984	0.0050	0.0032	0.1183	0.0735
	(1.82)	(1.77)	(0.96)	(0.59)	(3.37)	(2.03)
Firm age (log)	0.0316	0.0147	-0.0002	-0.0008	0.0676	0.0581
	(2.87)	(1.05)	(-0.19)	(-0.61)	(8.19)	(5.86)
Number of business segments (log)	0.0272	0.0161	0.0011	0.0013	0.0295	0.0182
	(2.15)	(1.26)	(0.84)	(0.98)	(3.19)	(2.00)
Market-to-book (log)	0.0054	-0.0024	0.0001	0.0004	-0.0457	-0.0415
	(0.47)	(-0.20)	(0.10)	(0.28)	(-5.11)	(-4.43)
R&D expenditures	0.0571	0.2602	0.0249	0.0370	-0.5089	-0.6790
	(0.24)	(1.06)	(0.99)	(1.34)	(-2.89)	(-3.57)
Stock return variance	0.1895	0.1618	0.0023	0.0005	-0.1330	-0.1184
	(3.98)	(3.45)	(0.52)	(0.11)	(-4.54)	(-3.59)
Free cash flow	0.0262	0.0297	0.0257	0.0253	0.0892	0.0984
	(0.17)	(0.17)	(1.97)	(1.77)	(0.86)	(0.85)
Return-on-assets	-0.4269	-0.4495	-0.0279	-0.0189	-0.3287	-0.3241
	(-2.51)	(-2.43)	(-1.78)	(-1.11)	(-2.73)	(-2.49)
CEO ownership		-0.5782		-0.0568		-0.5043
		(-2.59)		(-2.94)		(-2.95)
CEO tenure		-0.0045		0.0003		0.0006
		(-3.14)		(2.28)		(0.62)
Governance index (GIM)		0.0043		-0.0003		0.0107
		(1.17)		(-0.90)		(4.25)
Institutional ownership		-0.0878		-0.0118		-0.0486
		(-2.52)		(-3.25)		(-2.13)
Institutional Herfindahl		-0.0524		0.0331		0.1663
		(-0.36)		(2.22)		(1.79)
R^2	0.091	0.110	0.006	0.011	0.329	0.333
N	4,827	4,236	5,031	4,744	8,923	7,034

Table 10
Board Independence and Probability of Informed Trading: Takeover Defenses, Institutional Ownership, Firm-Specific Knowledge, and Pay-Performance Sensitivity

Estimates of OLS panel regressions of the logistic transformed fraction of independent directors are shown. The high and low governance index (GIM) samples consist of those firms whose GIM is above 13 and below 6. The high and low institutional ownership Herfindahl index samples consist of those firms whose institutional ownership Herfindahl index is above the 80th percentile and below the 20th percentile. The high (low) R&D sample consists of those firms whose ratio of R&D expenditures to assets is above (below) the 80th percentile. The high and low CEO pay-performance sensitivity (PPS) samples consist of those firms whose PPS is above the 80th percentile and below the 20th percentile. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High GIM	Low GIM	High inst. Herfindahl	Low inst. Herfindahl	High R&D	Low R&D	High PPS	Low PPS
Probability of informed trading	0.1013	-1.4477	-1.2607	-0.2797	-0.7576	-1.4648	-1.4779	-0.1044
	(0.08)	(-2.08)	(-2.72)	(-0.50)	(-1.21)	(-5.05)	(-2.58)	(-0.14)
Firm size (log)	0.0506	0.0269	0.0164	0.0520	0.0311	0.0439	0.0244	0.0067
	(0.98)	(0.67)	(0.63)	(1.63)	(1.02)	(2.66)	(0.83)	(0.22)
Leverage	0.6190	0.5675	0.4331	-0.0773	-0.0648	0.3444	0.2760	0.5776
	(1.77)	(2.46)	(2.90)	(-0.39)	(-0.34)	(2.89)	(1.76)	(2.29)
Firm age (log)	-0.0633	0.1009	-0.0199	0.1365	0.1208	0.0945	0.1333	0.1912
	(-0.54)	(1.52)	(-0.46)	(2.46)	(2.00)	(3.21)	(3.32)	(2.61)
Number of business segments (log)	0.1299	0.1851	0.1720	0.0418	0.1571	0.0592	0.1347	-0.0188
	(1.44)	(2.55)	(3.95)	(0.92)	(3.10)	(2.30)	(3.16)	(-0.42)
Market-to-book (log)	0.0046	0.0324	0.0821	-0.0017	0.0275	0.0327	-0.0032	0.1030
	(0.06)	(0.61)	(2.18)	(-0.04)	(0.69)	(1.31)	(-0.08)	(1.91)
R&D expenditures	3.8049	0.2791	-0.4451	1.1160	0.1360	3.8646	-0.1081	-0.1665
	(1.81)	(0.21)	(-0.60)	(1.34)	(0.18)	(1.62)	(-0.19)	(-0.18)
Stock return variance	-0.0877	-0.0210	0.1380	-0.2239	-0.0423	0.0237	-0.0505	-0.1552
	(-0.24)	(-0.07)	(1.74)	(-1.49)	(-0.25)	(0.36)	(-0.41)	(-0.58)
Free cash flow	0.5184	-0.9381	-0.2632	0.4504	0.2941	-0.0154	0.7072	0.5388
	(0.48)	(-1.37)	(-0.61)	(0.84)	(0.38)	(-0.05)	(1.28)	(0.88)
Return-on-assets	-0.2561	1.1769	0.2768	-0.3990	-0.4283	-0.2363	-0.8135	-2.2678
	(-0.18)	(1.45)	(0.55)	(-0.67)	(-0.54)	(-0.60)	(-1.47)	(-3.06)
CEO ownership	-3.2201	-1.8107	-1.1028	-3.3888	-2.4752	-1.7124	-2.5069	-0.8020
	(-2.03)	(-2.72)	(-2.25)	(-2.38)	(-1.51)	(-4.31)	(-4.82)	(-0.88)
CEO tenure	-0.0043	0.0001	0.0081	0.0005	-0.0083	-0.0050	-0.0098	-0.0113
	(-0.57)	(0.02)	(1.48)	(0.09)	(-1.43)	(-1.74)	(-2.28)	(-2.43)
Governance index (GIM)	0.1700	0.0887	0.0636	0.0206	0.0378	0.0392	0.0328	0.0229
	(2.24)	(1.36)	(5.27)	(1.72)	(3.13)	(5.06)	(2.75)	(1.68)
Institutional ownership	0.3807	0.0856	0.1868	-0.2233	0.1975	0.0446	0.0313	0.2167
	(1.91)	(0.46)	(1.46)	(-0.80)	(1.56)	(0.66)	(0.31)	(1.71)
Institutional Herfindahl	-1.4804	-0.3847	0.4562	1.4879	0.3998	0.2157	0.6879	-0.9390
	(-1.90)	(-0.86)	(1.77)	(0.19)	(0.88)	(0.86)	(1.68)	(-1.43)
R^2	0.409	0.424	0.282	0.234	0.260	0.203	0.195	0.186
N	437	615	1,342	1,255	1,305	5,433	1,241	1,241

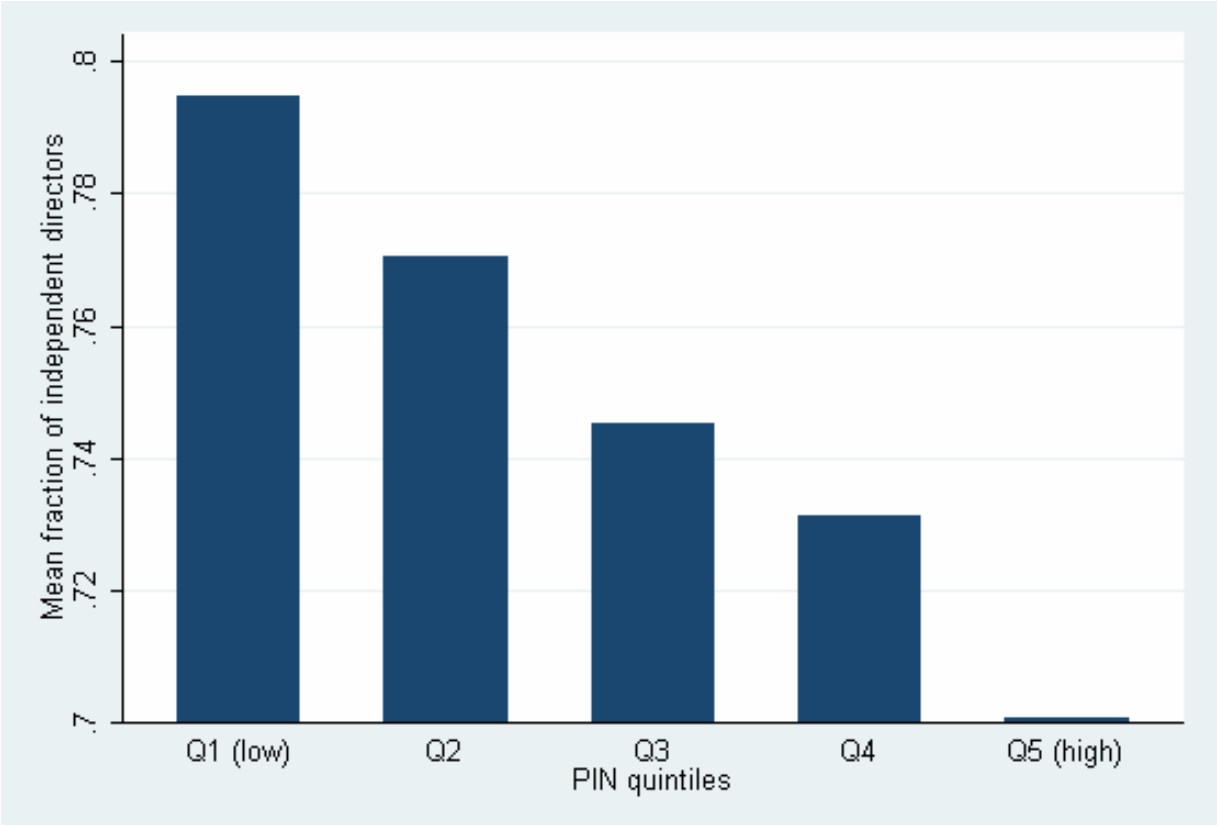

Figure 1. Board Independence by Probability of Informed Trading Quintiles. This figure plots the mean fraction of independent directors by probability of informed trading (PIN) quintiles for the period from 1990 to 2001.